Vitellogenin as a parameter of honey bee colony vitality

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24 Sept. 2011
<table>
<thead>
<tr>
<th>Individual bees / hoarding cages</th>
<th>Colony</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age related physiological condition</td>
<td>Super organism</td>
</tr>
<tr>
<td>Early death first week 20-50%</td>
<td>Trophallaxis</td>
</tr>
<tr>
<td>Queen less stress</td>
<td>Feed back mechanisms</td>
</tr>
<tr>
<td>Number of bees</td>
<td>Age related physiological condition</td>
</tr>
</tbody>
</table>

Vitality individual bees / colony
Parameters vitality colony

- Hemolymph protein
  - Vitellogenin
  - HSP
  - Immune related proteins
    - Defensin-1
    - Hymenoptaecin
    - abaecin

- # worker bees
- # cells sealed brood
- # cells bee bread
- Food gland development
- Fat-protein body
- others
Why vitellogenin as parameter of the vitality of a honeybee colony?

- Main storage protein (91% protein, 7% fat and 2% sugar).
- Larvae, queen, workers and drones feed.
- Conversion of yolk protein to larval food is compatible with the physiological condition of the nurse bee.
- Increase in vitellogenin reverses immunosenescence.
- The vitellogenin titer in winter bees is relatively high.
- The winter bees of European honey bees, *Apis mellifera*, have a relatively high vitellogenin titer. The feature to build up vitellogenin is an evolutionary adaptation and an important condition in order to live long and survive the winter.
Vitellogenin

Vitellogenin, bees, sealed brood cells are related to each other via feedback systems.

Therefore study of vitellogenin, in combination with # bees, # brood on colony level, to establish whether disrupting factors affect vitellogenin synthesis.
Colony protein / vitellogenin assessment

Sample size per colony: 25 bees

Analysis: Phast electrophorese system
Vitellogenin can be expressed as

1. $\mu g$ vitellogenin / $\mu l$ hemolymph

2. Percentage vitellogenin of total hemolymph protein
Why the parameter: vitellogenin percentage?

Significant correlation between total hemolymph protein and vitellogenin titer.

However, hemolymph with a certain amount of protein can have relatively more or less vitellogenin (expressed as percentage).
- The result of better or worse capability to synthesize vitellogenin due to
  1. Varroa? (individual proven, colony ?)
  3. pollen amount and diversity? (individual proven, colony?)
  4. pesticides (hormone analogues)
  5. others

Due to natural variation (age class distribution, environment) only an **overall reduction** of the percentage vitellogenin can be detected on **colony level**
Vitellogenin percentage, brood and Varroa (2008 study)

No different # brood, different mite fall          diverging vitellogenin perc.
Correlation mite fall and vitellogenin perc.

Table xx. Correlation between perc. vitellogenin (response variate) and mean daily mite fall 3-week prior to vitellogenin analysis. GLM. $P \leq 0.05$

<table>
<thead>
<tr>
<th>Period</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>0.33</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>0.13</td>
<td>0.09</td>
</tr>
<tr>
<td>Sept</td>
<td>0.05</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Hemolymph protein, vitellogenin and protein feed

- 6 days bees (lab test 120 bees)
  - beebread 27.57 µg protein / µl, 68.76 % vitellogenin
  - soya/yeast 24.06 µg protein / µl, 47.40 % vitellogenin
  - pollen 11.36 µg protein / µl, 26.85 % vitellogenin
  - corn 3.98 µg protein / µl, 10.96 % vitellogenin
  - sugar 2.17 µg protein / µl, 5.48 % vitellogenin
Vitellogenin and pollen flow (study 2009)

discontinuous pollen = pollen trap in June and August

bees

sealed brood cells

ratio bees : sealed brood cells
daily mite fall
Vitellogenin perc and pollen flow (study 2009)

- Discontinuous pollen flow
  - no significant impact on # bees, # brood and daily mite fall;
  - diverging ratio bees / brood;
  - trend correlation perc. vitellogenin – ratio bee / brood
  - Significant different perc. Vitellogenin on colony level
  - Colonies, looking similar in Sept can have different vitality

<table>
<thead>
<tr>
<th>date</th>
<th>ratio bees / brood</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-aug</td>
<td>0.77</td>
<td>0</td>
<td>0.77</td>
</tr>
<tr>
<td>30-sep</td>
<td>0.1</td>
<td>0.16</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Two apiaries in a pollen divers and a simple pollen environment.

In September pollen diversity at apiary PW is very low, almost unifloral (95%)

Pollen flow varied

<table>
<thead>
<tr>
<th>date</th>
<th>Grebbedijk (6 colonies)</th>
<th>Planken Wambuis (5 colonies)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>29-Jul</td>
<td>15.89 (9.49)</td>
<td>4.25 (2.46)</td>
<td>0.03</td>
</tr>
<tr>
<td>13-Aug</td>
<td>5.56 (3.69)</td>
<td>11.54 (7.88)</td>
<td>0.13</td>
</tr>
<tr>
<td>27-Aug</td>
<td>0.16 (0.14)</td>
<td>0 (0)</td>
<td>0.04</td>
</tr>
<tr>
<td>10-Sep</td>
<td>0.488 (0.91)</td>
<td>9.516 (10.67)</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Vitellogenin and pollen diversity (environment) (2010)

- Normal development colonies
- Stagnating # bees
- Significant more brood in September
Vitellogenin and pollen diversity (environment) (2010)

**July.**
Significant different ratio (more brood pollen rich environment), no significant difference perc vitellogenin

**September.**
Diverging ratio (more brood in poor pollen divers environment), significant different perc. Vitellogenin

Looks logic but

1. Colonies low perc. vitellogenin have not yet made transition to winterbees and the others have

2. Is low pollen diversity cause of low perc vitellogenin → continuous brood → no transition to winterbees?
Summary (1)

In **September** (in the Netherlands transition period summer to winterbees)

- negative correlation perc vitellogenin and daily mite fall.
- Continuous pollen flow in significant higher perc vitellogenin
- Colonies, looking similar of bees and brood can have significant different perc. vitellogenin less vital winter population
- Pollen divers environment results in significant higher perc vitellogenin
- Ratio # bees / # sealed brood cells in vital colonies = approximately 15
Summary (2)

- In September the mean colony percentage vitellogenin is a feasible parameter to establish colony vitality as result of varroa infestation and pollen flow – diversity (environment).
- Impact of pesticides in study.

- Is relatively low mean colony perc vitellogenin in September (threshold?) the cause of continuous breeding and delayed transition to winter bees?